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ABSTRACT

Predicting that the teaching-learning process in American higher education is about to change drastically because of continuing innovations in computer-assisted technology, this paper argues that this change will be driven by inexpensive but powerful computer technology, and that it will manifest itself by reducing the traditional timing of passage through the levels of the cognitive domain. Changes already taking place are reviewed, beginning with the use of the calculator rather than the slide rule. The impact of computer-assisted technology on the learning/teaching process is then discussed in terms of the cognitive levels specified by Bloom, including knowledge and comprehension, application, analysis, synthesis, and evaluation. Examples are given for each level. Other topics discussed include problems at the application level; costs; factors involved in the selection of the most appropriate computer systems; copyright protection; data protection; the impact of large, well cross-referenced databases and expert systems on scholarship; local area and other types of networking; and such administrative issues as change of traditional semester times, new disciplines, and changes in testing to reflect the new emphasis on synthesis, analysis, and evaluation that will be made possible by the use of computers in instruction. (RP)

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THE INCREASING EFFECTS OF COMPUTERS ON EDUCATION

By: John F. Gannon

The teaching-learning process in American higher education is about to change drastically because of continuing innovations in computer-assisted technology. This drastic change will be driven by inexpensive but powerful computer technology and will manifest itself by reducing the traditional timing of passage through the levels of the cognitive domain.

For many years Bloom's Taxonomy of the Cognitive Domain has been used as a model for showing a person's learning path. It has been an aid for many pedogogical constructions including "behavorial objectives" and "competency-based instruction."

A personal precis of Bloom's Cognitive Domain:

Evaluation - Developing standards for systems

Synthesis - Creating a whole where none existed

Analysis - Understanding the relationships between systems

Application - Predicting and effecting changes in systems

Comprehension - Understanding the underlying systems behind knowledge

Knowledge - Basic memorizing of data

Long the dream of many educators, synthesis and evaluation may become the most used levels in the cognitive domain.

How soon will the present technologies make drastic change in American higher education? The fact is the change has already started and is increasing every year. What kind of changes will take place? In the past application of the slide rule with hard-to-read logarithmic scales acted as a barrier for many students. The capability of the pre-computer calculator to do powers, trigonometric functions and factorials allowed slide

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rule shy students to compete in mathematics and science programs. Because of hand held inexpensive calculators we now have people using and teaching mathematics and science who never had to use a slide-rule during their training.

The next major change was brought on by a personal computer-assisted technology reducing the long training periods once needed to learn how to use the tools of a given discipline. Electronic spread sheets, slick graphics and word processing are existing examples. With the spread sheet the power of the calculator is multiplied by displaying all the steps in a computation and causing all the data to constantly change as the input is changed. Esoteric models or templates for both spread sheets and word processing are now advertised at reasonable prices and are available to students. By using specific models of templates for specific purposes, students can have the assistance of an expert setting up the steps to handle the specific purpose; all the student needs to do is enter the correct data and evaluate the answer.

A further change will take place because of industry's ventures into using artificial intelligence (AI) studies in the hope of building robotic factories. At this moment, except for some limited applications, the hope of having machines doing human-like thinking is still just a dream, but the research is spinning off many practical systems. Some of these, like expert systems, telecommunications systems, voice recognition systems, and pattern recognition systems, can be used in education as the price goes down.

An advertisement for "lst-CLASS," an expert system, reads: "Few resources are as valuable to your organization as the knowledge and expertise of your key people. That's why it makes sense to capture that expertise with lst-CLASS - so it can be available whenever and wherever needed."

These expert systems, at this moment, give users the ability to enter the program and reveal the logic behind the decisions. This ability will allow students to observe and learn from a variety of ways of solving problems.

Meanwhile, telecommunications systems will provide quick access to large cross-indexed data bases. These data bases already contain constantly updated information on anything from sports statistics to complete encyclopedias, to stock market quotations and defense contracts. Soon, whatever people can measure and encode on magnetic media will be available. For people learning to synthesize, the possibilities for interconnecting ideas with these data bases are infinite.

Impact on learning/teaching: How will knowledge, comprehension, application, analysis, synthesis, and evaluation levels of the cognitive domain be affected? Knowledge and comprehension, traditional bottlenecks to learning will be the first levels to open. Facts, the basic units of the knowledge level, are stored in data bases. Formulas, the mathematical analog of comprehension, are built into software allowing students access to mathematical reasoning as they are using the software. Because it is easy to understand what is happening on a well labeled spread sheet, where we can watch the input change as it follows the programmed algorithm (a recipe for computational procedure) on the template, comprehension will be quicker.

With a template-driven spread sheet, every step graphically explains itself and its relationship to the whole. The concept of powers, roots and reciprocals, once opaque to many students, now visibly increase or diminish data as it passes on the screen. It is even possible to slow down the process and follow each step in the algorithm.

Today's slick graphics are much improved visual aids; some programs with graphics are capable of being interactive with a student's curiosity. As more and more teachers tinker with and become proficient at developing software, more user-interactive software will aid passage through the knowledge and comprehension levels.

Application, once the realm of the practitioner with many hours of practice, can be used almost immediately with computers. CAD (computer-aided-drafting) and word processing are excellent examples. Word processing programs and templates for specific uses have helped many students to better present their views.

At an international users conference of Holguin CAD software there were two diametrically opposed viewpoints held by the participants. One group of users wanted to hire only untrained high school graduates to operate their CAD programs. The other group was dedicated to the premise, ". . . only advanced engineers would use this powerful equipment." At first, this did not make sense; why the split with no middle ground? We know it takes time for high school students to gain proficiency in drafting. Most beginning drafters, with just high school training, or maybe a course or two in college, take a reasonably long apprentice period before they are considered drafters. Could it be the computer making the difference? We can easily sense the impact in our society as computers changed from those early models with large whirling tape drives and huge consoles with blinking lights to the present desk-top size. While computer size decreased, computer processing power increased. The computer has changed traditional progress patterns in mastering application.

Both of the user groups were correct. The CAD programs have the capabilities to be learned easily, yet can expand far. On one level, it does

not take long to have untrained, moderately paid people making money for your company. On another level, the potential of CAD is increased by letting a company's best brains and most experienced designers use the software. Evidence of this expandable potential is the almost daily proliferation of CA (computer-assisted) technologies. Such as:

CAD. . . Computer-aided Drafting

CADD . . Computer-aided Drafting and Design

CAE. . . Computer-aided Engineering

CAMM . . Computer-aided Machining and Manufacturing

CIM. . . Computer Integrated Manufacturing

CNC. . . Computer Numerically Controlled (machines)

And on this abbreviated list are merely the titles. Each of these has spawned a myriad progeny of protocols, peripherals, and networks. Time between significant computer changes no longer is considered in increments of one year. Similar lists are made and then dwarfed by the lists made the following month.

Analysis is perhaps the most likely tool to be used in building an efficient evaluation scheme for students using the new application tools. The constant comparisons of students' work to accepted work is a powerful analysis tool. In the past, so much of a student's comparisons were incomplete because the student could not quickly master the application medium to the level of professional work. Therefore, nuances of the professional's work were not analyzed bacause they were not measurable by beginners. Now, given the computer and its programmed ability to mimic experts at the application level, students can apply the medium faster and learn more detail.

Synthesis enables students to build their own models for solving problems using spread sheets, word processors and graphics. Modeling, a way

of showing ". . .a new whole," will be available to instructors. When writing objectives for synthesis, teachers use such verbs as: plan, design, assemble, construct, and model. But without funds for materials and a demonstration medium, the majority of students could not do modeling other than in a illustrated paper outlining and describing what they had in mind. With the computer and simplified software they can have simulated materials and a demonstration medium to use in their models. Granted, it takes time to learn the software but the learning is cumulative. As students learn how to use one software package they learn techniques making the next package easier to use.

Evaluation, once seen at the top of the cognitive hierarchy may be better realized as a partner of analysis, and the two can be used by students at every stage of cognitive learning. If students' accounting models, running on a spread sheet with a special template, turn out ridiculous data, students will know how to evaluate the model. If students' designs on a CAD system can only be built on the two-dimensional screen of the monitor, then everyone will know how to evaluate the model.

Because computer-assisted technology aids students in making a "pretty image," emphasis on understanding what is behind the "pretty image" will become important. "Is the document correct as well as pretty?" should become an efficient question.

Again, as AI involves self-testing diagnostics as part of the design, you are able to check the logic flow. Soon we may see similar tools in educational programs.

Problems: Problems, at the applications level, will occur as the computer-assisted technology becomes more prevalent in Education. For

some instructors this rapid technological change, where computers running easy to use software replace long-ago learned and mastered skills in a keystroke, is frightening. One example seen in drafting is the drawing of geometric figures. An ellipse or a pentagon, drawn accurately and manually require time and skill; on a CAD program there is a single keystroke for each figure which is instantly & precisely drawn.

For teachers who have labored long to figure out all the complicated segments of their discipline, students operating in this electornic microprocessed world seem somehow to be cheating. "How will the student ever know if the drawn image is correct if they are not required to build it up from its elements?" is a statement repeatedly heard from concerned teachers. Are they correct in believing students will not be able to judge the validity of answers becuase they do not know how to put in data and take out answers?" "Where will the users of calculators be when the power goes out?" or "If there is a glitch in the software giving random wrong answers, how will the user know?"

These are not the only questions. History shows the futility of standing in the way of new technology. A better question would be: How can we effectively teach students evaluation practices to keep up with the not-to-be-stopped technological changes? Maybe the concept of proofs will return.

Costs: Initial costs of machines are only the first part of the problem. Changing hardware and interconnection standards to access new computer-related devices will constantly create situations in which functional equipment will be rendered obsolete. Slide rules quickly become decorations, 8 bit processors and 64k memories are being replaced by 16 bit and 256k memories and a 32 bit processor is just beginning to appear in desk-top computers. If organizations need to be competitive, keeping up is going to cost

money, big money.

Another part of the problem is: What system of computers is the best? A complex problem, some consultants suggest a main-frame system with standardized terminals, others suggest specific brand microcomputers; but to select, by a policy to save initial costs, a general-purpose computer system is to limit some departments with differing needs. Business departments may want IBM's or clones, education departments, the Apple family to prepare their student teachers for the computers available in most public schools.

Engineering, Mathematics and Science departments will require faster and faster processors with constantly expanding memory. Industrial departments will want LANs (local area networks), linking many types of computers, machines and assembly lines while offering online quality assurance capabilities.

Telecommunications networks are starting to enter the education field. Once just an add-on, the modem (modulator/demodulator) is quickly becoming a way to transmit data fast, far and frugally.

Copyright protection: What monitoring is necessary to protect disks in a library lent out to students and faculty? How do you protect yourselves from loss of classroom programs when new users destroy a disk yet you are not allowed to have made a backup disk? The arguments of users versus producers of software are taking place right now in industry, libraries, schools, and the courts.

Data protection: How much effort are schools ready to expend to protect electronic bulletin boards of LANs where tests and research data may be stored and subject to discovery, copying, and proliferation?

Scholarship: What will the proliferation of large, well cross referenced data bases do to the concepts of original work and research. The long time learning a language to read documents in the original could be replaced by the quick learning necessary to use translation software and then reading the documents in your own language. Real time translation (two people with different languages communicating using a computer) is difficult due to context and syntax problems but translating existing books is only a matter of time and money.

Another way scholarship will be affected is from an even more powerful tool than spread sheets. It's the "expert system." Expert systems range from systems to operate the cooling towers at Campbell Soup Company to systems to operate high speed aircraft during violent maneuvers where the pilot is momentarily blacked out and unable to make decisions concurrently. Most are expensive, like the technology before them and are not available to college students. But, also like the technology before them, the cost is decreasing, and more available memory will soon bring them within reach of students and scholars. Designers claim these systems contain cross-indexed methods used by experts to attack specific problems. Will people be accused of plagiarism when they can legally open up the program and ask how certain decisions were made by the program developer? This capability to check decisions is built in so industry can investigate the weighting given each decision item. The expert's life work is now an open statement in a computer listing.

New Horizons: As previously mentioned, the computer-assisted networks, LANs (local area networks) are being introduced and used in colleges. From the Oct. 1986 issue of "Personal Computing": "At the University of

Texas at Austin, 'Classroom 2000' is one of the 13 IBM-grant college programs in information management, and one of more than 100 IBM-aided educational programs nationwide. The futuristic design - the glass-enclosed classroom is suspended from the lobby ceiling of the business school - showcases a dazzling marriage of hardware and software. The podium and each desk sport IBM PC at 370's all linked through a local area network, and can tap into national data bases. Work from the students' or professor's machine can be projected onto a seven by 10-foot screen, or the professor can use a digitizer pad for a desktop 'blackboard'."

Another type of network is the BBS system which can be used for off campus television studies linked to a BBS. One major complaint from the user of the present tv off-campus courses is the impersonal feeling of the course. A student able to leave messages on a board dedicated to a specific course would allow communication between student and instructor. The instructor would be able to leave E-mail (electronic-mail posted for designated people on a bulletin board) for helping specific students with questions.

Change of traditional semester times: To match the potential speed which people may learn we may see changes in traditional semester periods.

New disciplines: Already the data processing departments have spawned many new courses from keyboarding to spread sheet modeling and I suspect there will be many more in the industrial departments as CIM and CAM create a demand for operators.

New changes in testing: with the influx of data bases for knowledge items and templates for mathematical relationships, what will happen to the traditional tests to determine if students retained knowledge items and comprehended relationships?

The traditional course outline or syllabus objectives and evaluation procedures are mainly directed at these lower levels of the cognitive domain. Rarely do they address the synthesis level. It would seem there will be more concentration in testing for synthesis, analysis and evaluation in the educational future.

The thoughts presented here concentrate only on how computers are assisting students in the cognitive domain but similar changes can be imagined in the other domains. Simply put, easy passage through the lower cognitive areas should increase the "willingness to learn" from the affective domain. The simulation of events by computer, where mistakes are considered as "bugs" to be removed, will lessen the frustration and anxiety of performing tasks in the real world where mistakes can blow up and destroy costly material.

The consequences of computer-assisted technology being used in education will effect teachers who presently utilize the lower areas of the cognitive, affective and psychomotor domains. Curriculum and testing objectives will change. Analysis and evaluation will need to be stressed so students and lay people are not fooled into believing any answer presented by a computer program is correct.